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DIODE

STEP STRESS PROGRAM

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FINAL REPORT

FOR

JANTX1N981B

DECEMBER 1978

PREPARED FOR

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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FOREWORD

This report is a summary of the work performed on NASA Contract NAS8-31944. The investigation was conducted for the National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Huntsville, Alabama. The Contracting Officer's Technical Representative was Mr. F. Villella.

The short-term objective of this preliminary study of transistors, diodes, and FETS is to evaluate the reliability of these discrete devices, from different manufacturers, when subjected to power and temperature step stress tests.

The long-term objective is to gain more knowledge of accelerated stress testing for use in future testing of discrete devices, as well as to determine which type of stress should be applied to a particular device or design.

This report is divided as follows: description of tests, figures, tables, and appendix.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

1.0 INTRODUCTION/SCOPE

D.C.A. Reliability Laboratory, under contract NAS8-31944 for NASA/Marshall Space Flight Center, has compiled data for the purpose of evaluating the effect of power/temperature step stress when applied to a variety of semiconductor devices. This report covers the Zener diode JANTX1N981B manufactured by Motorola and Siemens.

A total of 48 samples from each manufacturer was submitted to the process outlined in Table 1. In addition, two control units were maintained for verification of the electrical parametric testing.

2.0 TEST REQUIREMENTS

2.1 Electrical

All test samples were subjected to the electrical tests outlined in Table 2 after completing the prior power/temperature step stress point. These tests were performed using the Fairchild Model 600 high-speed computer-controlled tester. Additional bench testing was also required on the devices.

2.2 Stress Circuit

The test circuit shown in Figure 1 was used to power all of the test devices during the power/temperature stress conditions. The voltage was set by V_Z and the current was varied in order to comply with the specified power rating for the device. Maximum rated power (MRP) was reached on at least one of the test devices. All the remaining devices were subjected to not less than 90% of the maximum rated power. See Figure 1 for load resistor values and voltages.

2.3 Group I - Power Stress

Thirty-two units, 16 from each manufacturer, were submitted to the Power Stress process. The diodes were stressed in 500-hour steps at 50, 100, 125, 150, and 175 percent of maximum rated power for a total of 2500 hours or until 50% or more of the devices in a sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each power step. See Table 1.

2.4 Group II - Temperature Stress I

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress I process. Group II was subjected to a total of 1600 hours of stress at maximum rated power in increments of 160 hours. The temperature was increased in steps of +25°C, commencing at +75°C and terminating at +300°C or until 50% or more of the devices failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

2.5 Group III - Temperature Stress II

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress II process. Group III was subjected to a total of 112 hours of stress at maximum rated power in increments of 16 hours. The temperature was increased in steps of +25°C, commencing at +150°C and terminating at +300°C or until 50% or more of the devices in a sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table I.

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*Conditions for failure:

A) Opens or shorts
B) Leakage exceeds maximum limit by 100 times.
C) Other parameters exceed MIL limits by 50% or greater.

3.0 DISCUSSION OF TEST RESULTS

3.1 Group I - Power Stress

3.1.1 Motorola. The Motorola sample lot completed the entire 2500-hour Group I testing with no catastrophic failures. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 22.47nA from an initial mean of 5.107nA to a final mean of 27.58nA.

2) The mean value for B_V changed .26V from an initial mean of 70.29V to a final mean of 70.03V.

The control units for this sample lot remained constant throughout the entire Group I testing.

3.1.2 Siemens. The SIE sample lot completed the entire 2500-hour Group I testing with no catastrophic failures. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed .236nA from an initial mean of .710nA to a final mean of .947nA.

2) The mean value for B_V changed .23V from an initial mean of 68.17V to a final mean of 67.94V.

The control units for this sample lot remained constant throughout the entire Group I testing.

3.1.3 Statistical Summary - Group I

Table 4 outlines the results of Group I - Power Stress for the two electrical parameters and all measurement points for both Motorola and Siemens.

3.2 Group II - Temperature Stress I

3.2.1 Motorola. The Motorola sample lot completed the entire 1600-hour Group II testing with a total of 10 catastrophic

failures. The first failure occurred 160 hours into the +225°C temperature step. Serial number 4687 failed the minimum B_V limit. The next failure occurred 160 hours into the +275°C temperature step. Serial number 4680 failed the minimum B_V limit. The last eight failures occurred 160 hours into the +300°C temperature step. Serial numbers 4677, 4683, 4688, and 4689 failed because of excessive I_R leakage. Serial numbers 4679 and 4684 failed the minimum B_V limit. Serial numbers 4678 and 4682 were removed from the Group II testing as visual failures because the diodes cracked in two from the stress. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 4.232µA from an initial mean of 8.675nA to a final mean of 4.232µA.

2) The mean value for B_V changed 13.54V from an initial mean of 70.14F to a final mean of 56.60V.

The control units for this sample lot remained constant throughout the entire Group II resting.

3.2.2 Siemens. The SIE sample lot completed a total of 1440 hours before the lot was stopped because more than 50% of the devices failed at this point. The first failure occurred 160 hours into the +175°C temperature step. Serial number 4625 failed because of excessive I_R leakage. The last eight failures occurred 160 hours into the +275°C temperature step. Serial numbers 4628, 4630, 4631, 4632, 4635, 4636, and 4637 failed the minimum B_V limit. Serial number 4638 failed because of excessive I_R leakage. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 57.669µA from an initial mean of 1.10nA to a final mean of 57.67µA.

2) The mean value for B_V changed 27.71V from an initial mean of 67.96V to a final mean of 40.25V.

The control units for this sample lot remained constant throughout the entire Group II testing.

3.2.3 Statistical Summary - Group II

Table 5 of this report outlines the results of Group II - Temperature Stress I testing for the two specified electrical parameters and all of the measurement points pertaining to both Motorola and Siemens.

3.3 Group III - Temperature Stress II

3.3.1 Motorola. The Motorola sample lot completed the entire 112-hour Group III testing with no catastrophic failures. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 19.727nA from an initial mean of 5.553nA to a final mean of 25.28 nA.

2) The mean value for B_V changed .02V from an initial mean of 69.91V to a final mean of 69.93V.

The control units for this sample lot remained constant throughout the entire Group III testing.

3.3.2 Siemens. The SIE sample lot completed the entire 112-hour Group III testing with a total of three catastrophic failures. The first failure occurred 16 hours into the +175°C temperature step. Serial number 4642 failed because of excessive I_R leakage. The last two failures occurred 16 hours into the +300°C temperature step. Serial numbers 4647 and 4651 failed the minimum B_V level. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 13.449µA from an initial mean of .8169nA to a final mean of 13.45µA.

2) The mean value for B_V changed 7.05 from an initial mean of 68.54V to a final mean of 61.49V.

The control units for this sample lot remained constant throughout the entire Group III testing.

3.3.3 Statistical Summary - Group III

Table 6 outlines the results of Group III - Temperature Stress II for the two electrical parameters and all measurement points for both Motorola and Siemens.

4.0 FINAL DATA SUMMARY

Table 7 statistically summarized the change in the mean value from the zero-hour data to the final data. The graphs of Figures 2 and 4 plot the cumulative percent failures versus the temperature stress level for Group II - Temperature Stress I, and Group III - Temperature Stress II. The graphs of Figures 3 and 5 plot the time step for Group II (160 hours) and Group III (16 hours) versus the temperatures T_1 and T_2 calculated from Figures 2 and 4. Tables 8 and 9 summarize the failures encountered for all three stress groups. The failures are separated into two catagories: catastrophic failures in Table 8 and parametric failures in Table 9. The data from Table 8 was used as a source for the graphs in Figures 2 and 4. Figures 2 and 4 were used as a source for the graphs in 3 and 5 respectively. Junction temperature is plotted on an inverse hyperbolic scale.

5.0 CONCLUSIONS

Both manufacturer's parts performed well in the Group I and Group III testings. The Group II - Temperature Stress I testing proved to be the most detrimental of the three groups. Motorola completed the testing with 10 catastrophic failures. The Siemens sample lot was stopped 160 hours before the completion of the Group II testing with a total of nine catastrophic failures. Extreme heat was a big

factor in the failure mode. Note that the majority of the failures did not occur until the +275°C of +300°C temperature step. At this point the devices experienced junction temperatures above +500°C. It is safe to say that the Motorola and Siemens devices failed due to electrical/ thermal overstress, damaging the internal diode junctions. This conclusion is supported by the presence of low breakdown with soft and resistive curve traces, and the absence of surface leakage.

A plot showing cumulative failure distribution for Groups II and III testing was drawn for the Siemens sample lot (Figures 4 and 5), but a complete graph could not be drawn for the Motorola sample lot because of an absence of failure points in the Group III testing. Figures 4 and 5 display the Siemens sample lot used to calculate an activation energy of .98eV.

A broken circle around a marked point, on the graph, indicates a freak failure not calculated as part of the regression line. A solid circle around a marked point indicates an isolated failure point. The regression line was drawn using the least square method.

The activation energy was calculated from the formula:

$$E = \left[\ell n \left(\frac{t_1}{t_2} \right) \right] \left[\frac{8.63 \times 10^{-5} \text{ eV/}^{\circ}\text{K}}{\left(\frac{1}{T_1 + 273} \right) - \left(\frac{1}{T_2 + 273} \right)} \right] \text{eV}$$

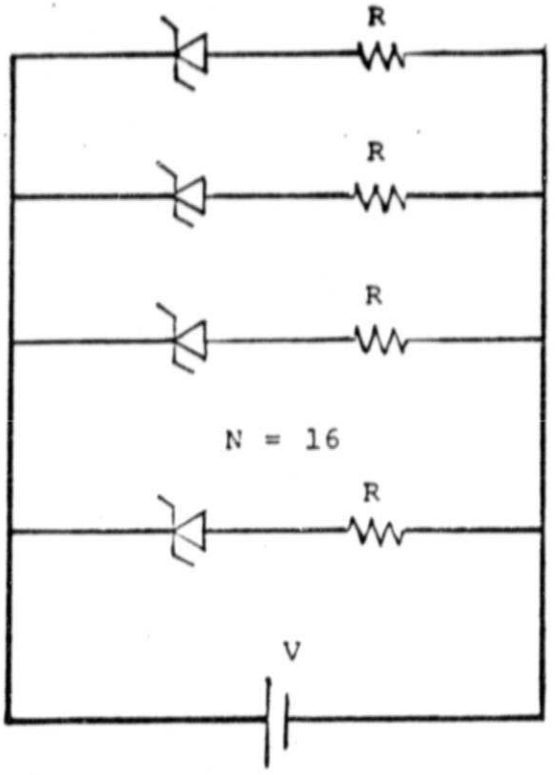
Where: t_1 = step of Group II - Temp Stress I = 160 hrs.

t_2 = step of Group III - Temp Stress II = 16 hrs.

T_1 = temperature in $^{\circ}$C of 16% failure for Group II.

T_2 = temperature in $^{\circ}$C of 16% failure for Group III.

ZENER DIODES



$R = V_Z \div 1.75\ I_{Z\ MAX} \pm 50\%$

$P_d = V_Z^2 \div R$

FIGURE 1
Power and Temperature Stress Circuit
for JANTX1N981B.

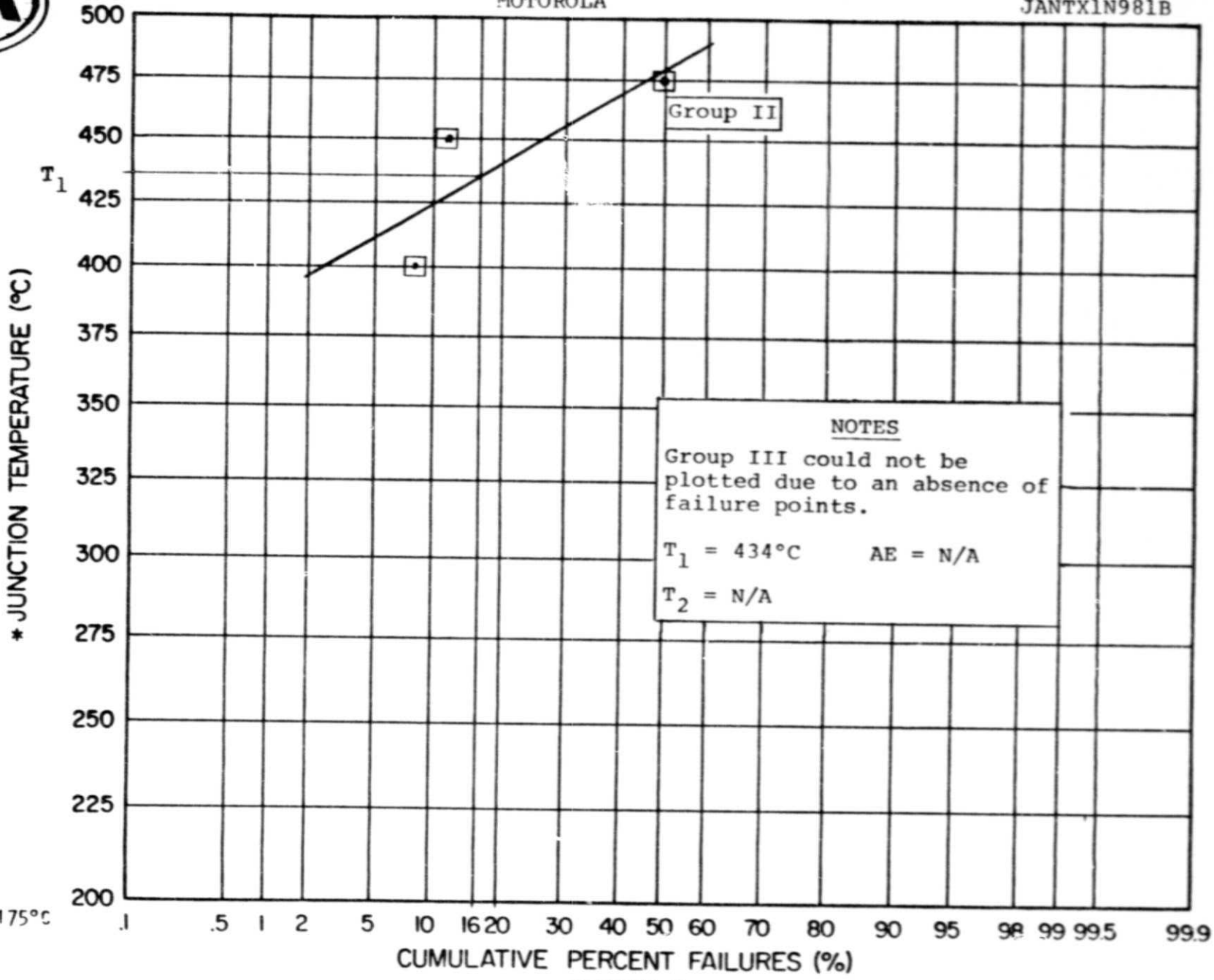


FIGURE 2
Cumulative Percent Failures Versus Junction Temperature, Motoròla

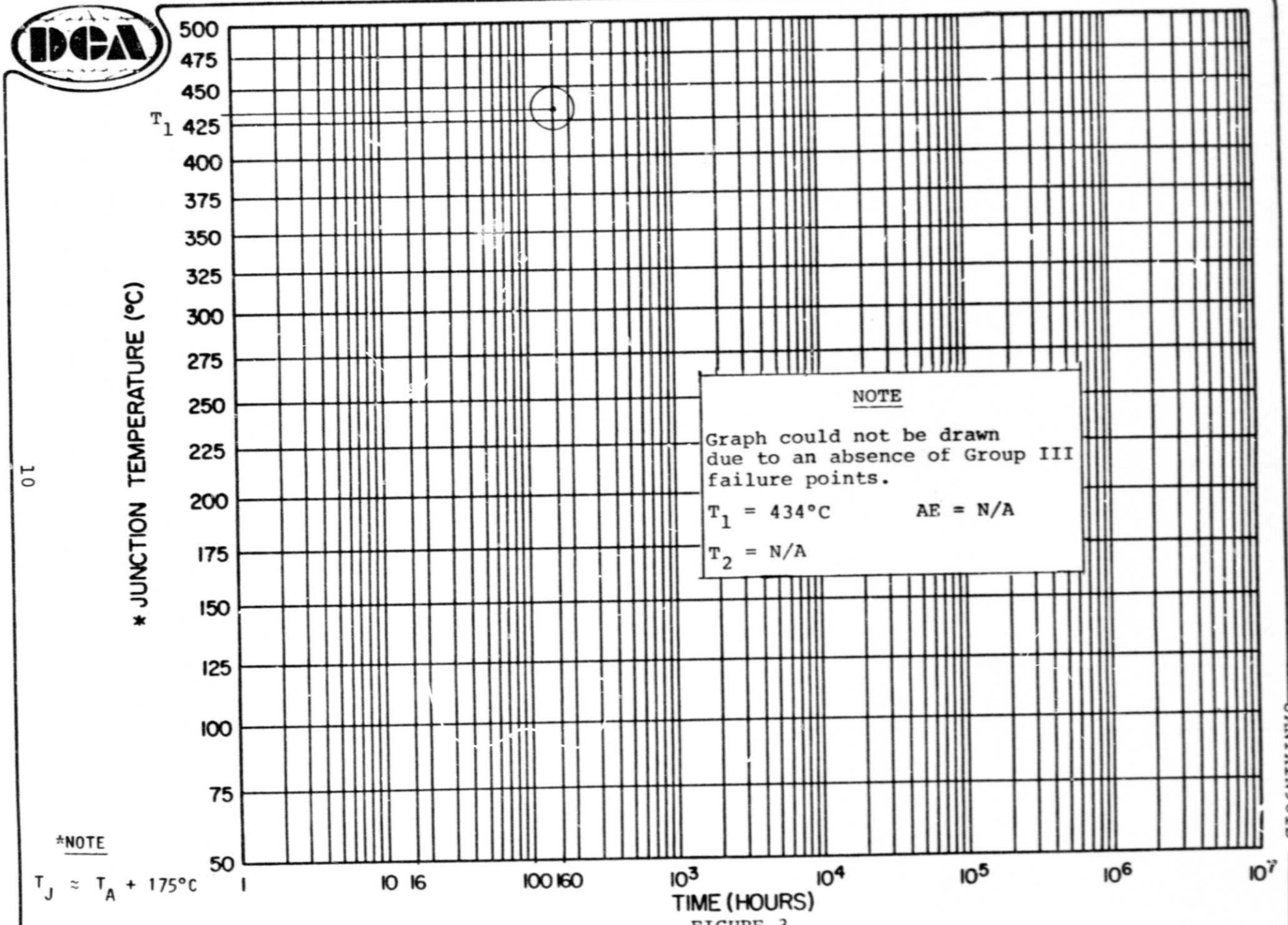
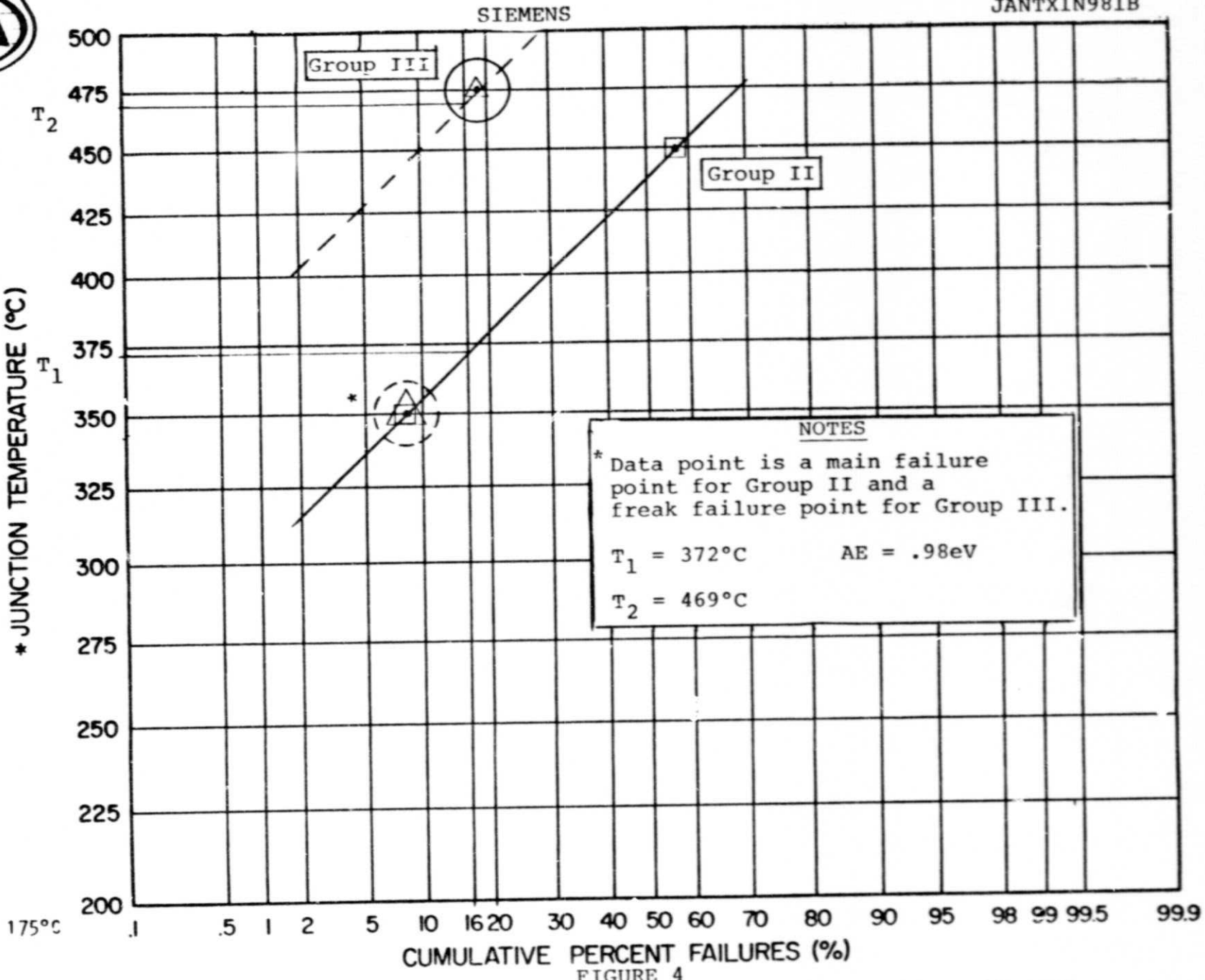


FIGURE 3
Time Steps Versus Junction Temperatue, Motorola

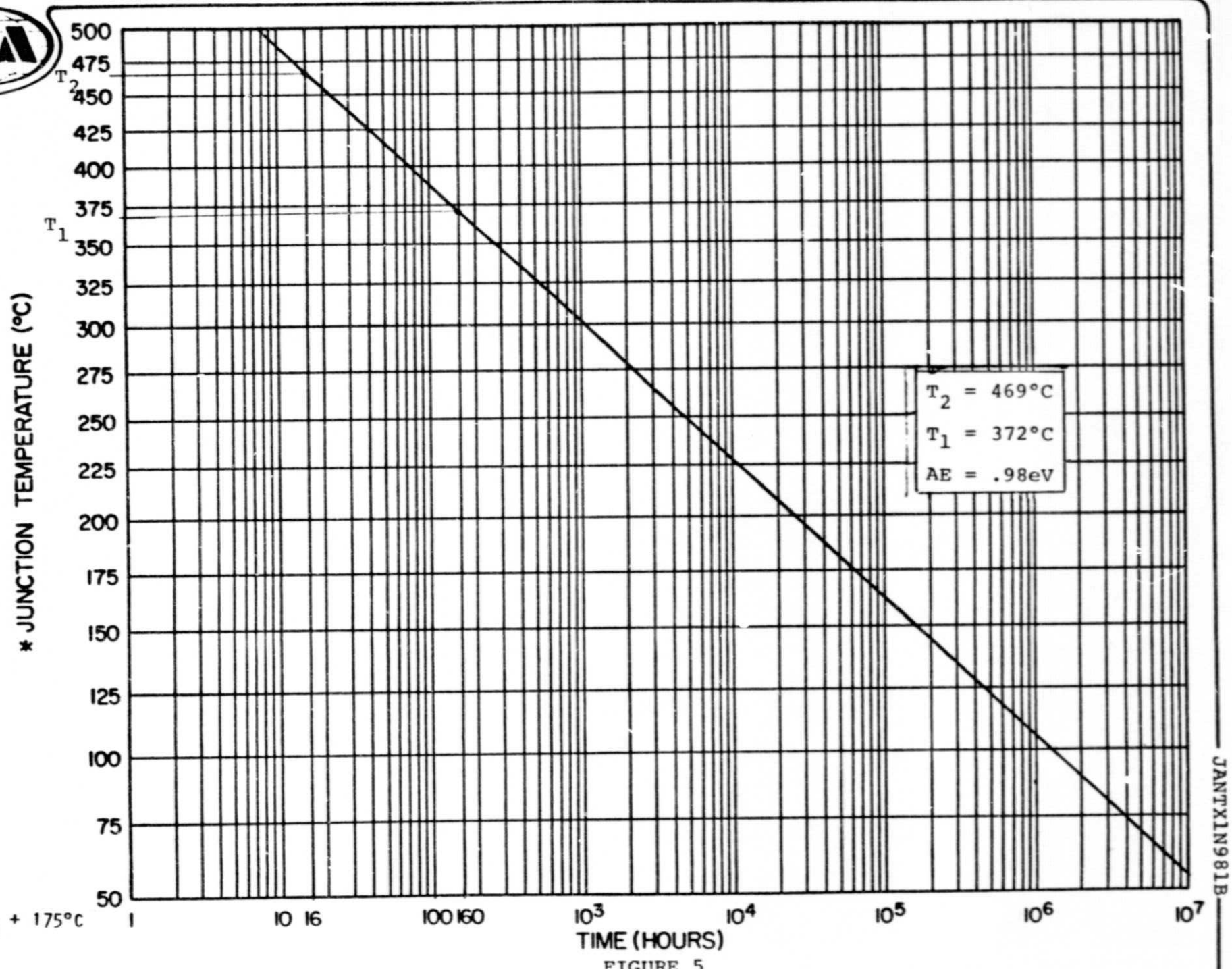


*NOTE

$T_J \approx T_A + 175°C$

FIGURE 4

Cumulative Percent Failures Versus Junction Temperature, Siemens



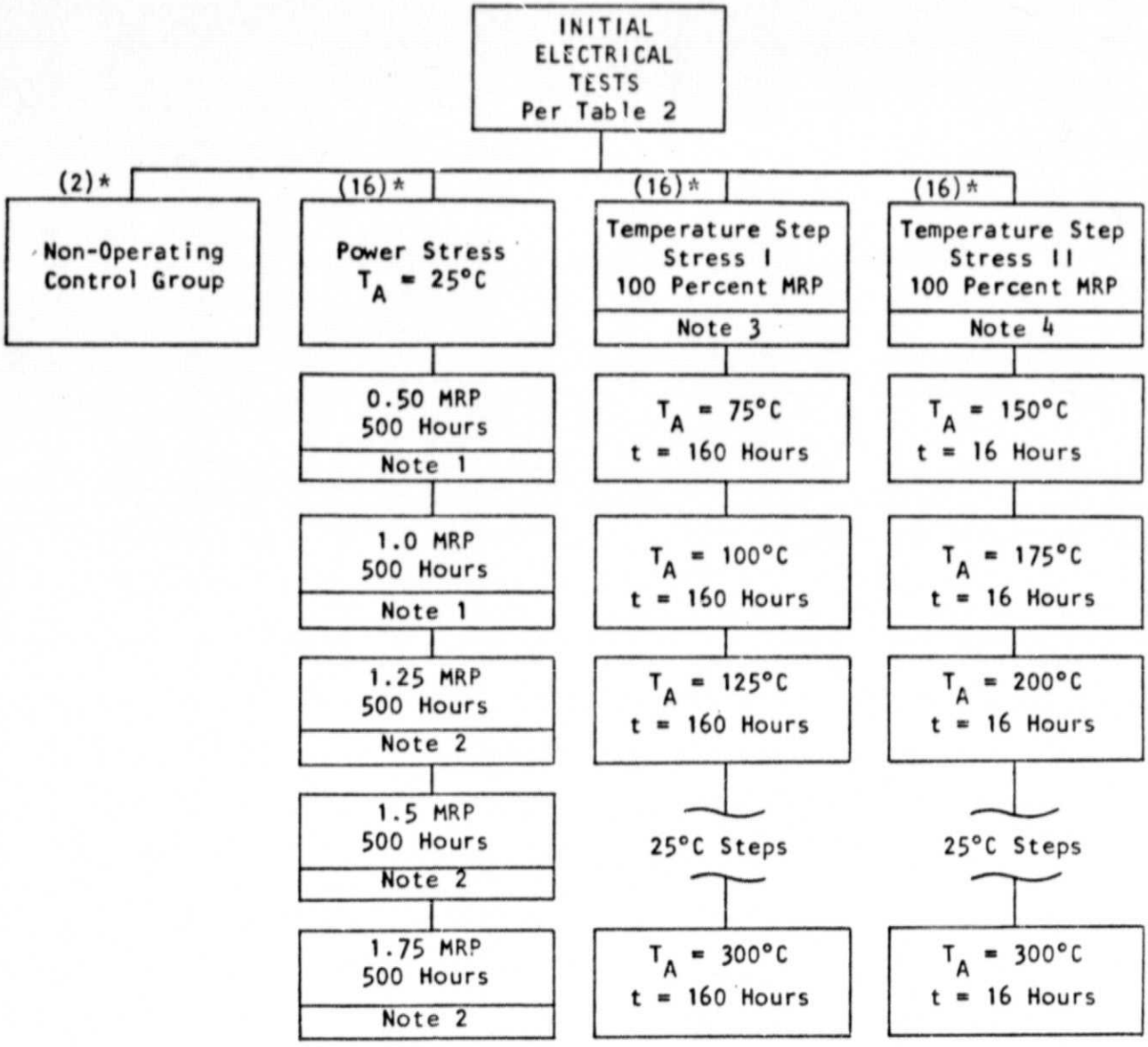
*NOTE

$T_J \approx T_A + 175°C$

FIGURE 5

Time Steps Versus Junction Temperature, Siemens

TABLE 1
TEST FLOW DIAGRAM



*Quantity per manufacturer (Motorola & Siemens)

NOTES:

1) Electrical measurements per Table 2 were made at 50, 150, 250 and 500 hours.
2) Electrical measurements per Table 2 were made at 10, 25, 50, 150, 250 and 500 hours.
3) Electrical measurements per Table 2 were made at the end of each 160 hours.
4) Electrical measurements per Table 2 were made at the end of each 16 hours.

TABLE 2
PARAMETERS AND TEST CONDITIONS

PARAMETER	CONDITIONS	SPEC. LIMIT		CAT. LIMIT*		UNITS
		MIN	MAX	MIN	MAX	
I_R	@ V_R = 52.0V	---	5.0	---	500.0	µA
B_V	@ I_Z = 1.8mA	64.6	71.4	32.3	107.1	V

NOTES:
*In addition, any open or short shall be considered catastrophic.

TABLE 3
POWER STRESS BURN-IN CONDITIONS

V_Z = 68.0V	
I_Z =	Percent P_D
2.7mA	50
5.4mA	100
6.8mA	125
8.1mA	150
9.5mA	175

NOTE
FOR TABLES
4 THROUGH 7

The minimum/maximum initial and final data generally have an absolute accuracy of ±1% of the reading and ± one digit except for readings greater than 9.99mA which have an absolute accuracy of ±2% of the reading and ± one digit. The data also has a resolution for four digits. The standard deviations, means, delta means, and average means are, therefore, valid indicators of trends over time and temperature, excepting the minor statistical computer error of supplying a constant number of significant digits.

TABLE 4
GROUP I – POWER STRESS DATA SUMMARY

PARAMETER	I_R = 5.0μA (max)		B_V=64.6V(min) 71.4V(max)					
CONDITIONS AND LIMIT	@V_R = 52.0V		@I_Z = 1.8mA					
IDENTIFICATION	MOTOROLA	SIEMENS	MOTOROLA	SIEMENS				
INITIAL DATA								
MIN VALUE	1.11nA	.180nA	69.37V	65.20V				
MAX VALUE	12.90nA	1.560nA	71.41V	70.15V				
MEAN	5.107nA	.710nA	70.29V	68.17V				
STD DEV	3.843nA	.304nA	.5302V	1.479V				
INTERIM DATA								
POWER 50 TO 125% Δ MEAN VALUE								
50% POWER								
50 hrs	-.585nA	.094nA	-.30V	-.07V				
150 hrs	-.668nA	-.063nA	-.06V	.06V				
250 hrs	-.926nA	-.102nA	-.12V	-.58V				
500 hrs	-.802nA	-.121nA	-.12V	-.01V				
100% POWER								
550 hrs	-1.062nA	-.171nA	-.35V	-.18V				
650 hrs	-1.305nA	-.278nA	-.29V	-.10V				
750 hrs	-1.429nA	-.176nA	-.27V	-.14V				
1000 hrs	- .546nA	-.049nA	-.32V	-.20V				
125% POWER								
1010 hrs	-2.150nA	-.283nA	-.18V	-.07V				
1025 hrs	-1.515nA	-.259nA	-.21V	.04V				
1050 hrs	-1.386nA	-.109nA	-.23V	-.11V				
1150 hrs	-1.662nA	-.162nA	-.20V	-.15V				
1250 hrs	-2.121nA	-.307nA	-.26V	-.35V				
1500 hrs	-1.661nA	-.158nA	-.18V	-.27V				

(continued on second sheet)

TABLE 4 (Cont'd)
GROUP I – POWER STRESS DATA SUMMARY

(continued from first sheet)

PARAMETER	I_R = 5.0μA (max)		B_V=64.6V(min) 71.4V(max)					
CONDITIONS AND LIMITS	@V_R = 52.0V		@I_Z = 1.8mA					
IDENTIFICATION	MOTOROLA	SIEMENS	MOTOROLA	SIEMENS				
INITIAL DATA								
MIN VALUE	1.11nA	.180nA	69.37V	65.20V				
MAX VALUE	12.90nA	1.560nA	71.41V	70.15V				
MEAN	5.107nA	.710nA	70.29V	68.17V				
STD DEV	3.843nA	.304nA	.5302V	1.479V				
INTERIM DATA								
POWER 150 TO 175% Δ MEAN VALUE								
150% POWER								
1510 hrs	- 1.422nA	- .119nA	- .08V	- .09V				
1525 hrs	- 1.714nA	- .193nA	- .12V	- .10V				
1550 hrs	- 1.993nA	- .301nA	- .11V	- .35V				
1650 hrs	- 2.108nA	- .211nA	- .25V	- .31V				
1750 hrs	- 1.866nA	- .183nA	- .11V	- .21V				
2000 hrs	- 1.991nA	- .239nA	- .21V	- .21V				
175% POWER								
2010 hrs	- 1.583nA	- .1[illegible]nA	- .15V	- .22V				
2025 hrs	- 1.367nA	- .092nA	- .14V	- .16V				
2050 hrs	- 1.509nA	- .100nA	- .09V	- .15V				
2150 hrs	- 1.711nA	- .153nA	- .12V	- .10V				
2250 hrs	- 1.901nA	- .188nA	- .33V	- .27V				
2500 hrs	22.47nA	.237nA	- .26V	- .23V				
FINAL DATA								
MIN VALUE	.170nA	.250nA	69.21V	65.08V				
MAX VALUE	387.0nA	5.530nA	70.76V	69.89V				
MEAN	27.58nA	.9469nA	70.03V	67.94V				
STD DEV	92.85nA	.205nA	.4771V	1.445V				

NOTE: Catastrophic Rejects removed from data.

TABLE 5

GROUP II TEMP STRESS DATA SUMMARY (160 HR. INCREMENTS)

PARAMETERS	I_R = 5.0μA (max)		B_V=64.6V(min) 71.4V(min)					
CONDITIONS AND LIMITS	@V_R = 52.0V		@I_Z = 1.8mA					
IDENTIFICATION	MOTOROLA	SIEMENS	MOTOROLA	SIEMENS				
INITIAL DATA								
MIN VALUE	1.650nA	.780nA	69.35V	66.06V				
MAX VALUE	60.800nA	1.410nA	70.98V	69.81V				
MEAN	8.675nA	1.100nA	70.14V	67.96V				
STD DEV	13.700nA	.2002nA	.5313V	1.129V				
INTERIM DATA (INITIAL TO FINAL)								
Δ MEAN VALUE (160 HR. INCREMENTS)								
Total Hrs / Temp (T_A)								
160 / +75°C	-3.193nA	.962nA	.03V	-.10V				
320 / +100°C	-1.741nA	6.247μA	.05V	-.05V				
480 / +125°C	-2.629nA	1.429nA	.00V	-.12V				
640 / +150°C	-2.582nA	4.638μA	.00V	-.10V				
800 / +175°C	-1.964nA	1.743nA	.04V	-.16V				
960 / +200°C	-2.128nA	1.324nA	.09V	-.05V				
1120 / +225°C	14.855nA	45.000μA	.23V	.01V				
1280 / +250°C	9.015nA	3.074μA	.36V	.01V				
1440 / +275°C	6.694μA	57.669μA	- 4.14V	- 27.71V				
1600 / +300°C	4.232μA	JOB STOPPED	-13.54V	JOB STOPPED				
FINAL DATA								
FINAL TEMP (T_A)	+300°C	+275°C	+300°C	+275°C				
MIN VALUE	2.460nA	2.360nA	11.56V	.100V				
MAX VALUE	9.990μA	99.900μA	71.19V	69.840V				
MEAN	4.241μA	57.670μA	56.60V	40.250V				
STD DEV	4.861μA	48.010μA	20.04V	29.480V				

NOTE: CATASTROPHIC REJECTS REMOVED FROM DATA

TABLE 6

GROUP III TEMP STRESS DATA SUMMARY (16 HR. INCREMENTS)

PARAMETERS	I_R = 5.0µA (max)		B_V=64.6V(min) 71.4(max)					
CONDITIONS AND LIMITS	@V_R = 52.0V		@I_Z = 1.8mA					
IDENTIFICATION	MOTOROLA	SIEMENS	MOTOROLA	SIEMENS				
INITIAL DATA								
MIN VALUE	.850nA	.2200nA	69.1300V	66.360V				
MAX VALUE	19.100nA	4.5200nA	70.9000V	70.390V				
MEAN	5.553nA	.8169nA	69.9100V	68.540V				
STD DEV	4.650nA	.9862nA	.5473V	1.164V				
INTERIM DATA (INITIAL TO FINAL)								
Δ MEAN VALUE (16 HR. INCREMENTS)								
Total Hrs / Temp(T_A)								
16 +150°C	-1.550nA	.459nA	.00V	-.10V				
32 +175°C	-1.112nA	6.244µA	.02V	-.05V				
48 +200°C	-1.063nA	.892nA	-.12V	-.17V				
64 +225°C	.540nA	1.166nA	-.22V	-.23V				
80 +250°C	- .461nA	1.136nA	-.14V	-.23V				
96 +275°C	1.823nA	1.273nA	-.12V	-.15V				
112 +300°C	19.727nA	13.449µA	.02V	-7.05V				
FINAL DATA								
FINAL TEMP (T_A)	+300°C	+300°C	+300°C	+300°C				
MIN VALUE	1.210nA	1.510nA	69.0800V	14.38V				
MAX VALUE	332.000nA	99.900µA	70.9800V	69.90V				
MEAN	25.280nA	13.450µA	69.9300V	61.49V				
STD DEV	79.300nA	33.910µA	.4407V	17.35V				

NOTE: CATASTROPHIC REJECTS REMOVED FROM DATA

TABLE 7
FINAL DATA SUMMARY

PARAMETER	SPECIFICATIONS LIMIT		UNITS	MEAN INT. DATA	AVERAGE Δ IN MEAN VALUE					
					POWER STRESS		TEMPERATURE STRESS I		TEMPERATURE STRESS II	
	MIN	MAX			MOTOROLA	SIEMENS	MOTOROLA	SIEMENS	MOTOROLA	SIEMENS
I_R	-	5.0	µA		-.00056	-.00015	+1.0936	+12.959	+.00256	+2.8140
BV	64.6	71.4	V		-.19462	-.17423	-1.6880	-3.1411	-.08000	-1.1400

NOTE: Catastrophic reject(s) removed from data.

JANTX1N981B

TABLE 8 STEP STRESS CATASTROPHIC FAILURE SUMMARY JAN TX1N981B

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
100% 50 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
125% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
150% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
175% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-

GROUP II 160 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75° C	0	-	0	-
100° C	0	-	0	-
125 °C	0	-	0	-
150 °C	0	-	0	-
175 °C	0	-	1	B
200 °C	0	-	0	-
225 °C	1	A	0	-
250 °C	0	-	0	-
275 °C	1	A	7/1	A/B
300 °C	4/2	B/A	C	JOB STOPPED

GROUP III 16 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150 °C	0	-	0	-
175 °C	0	-	1	B
200 °C	0	-	0	-
225 °C	0	-	0	-
250 °C	0	-	0	-
275 °C	0	-	0	-
300 °C	0	-	2	A

MFR "A" = MOTOROLA

MFR "B" = SIEMENS

NOTES:

(A) B_V <32.3V

(B) I_R >500μA

(C) Visual (other than handling)

TABLE 9 STEP STRESS PARAMETRIC FAILURE SUMMARY JAN TX1N981B

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	1	A	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
100% 50 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
125% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
150% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
175% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-

GROUP II 160 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75° C	0	-	0	-
100° C	0	-	1	C
125°C	0	-	0	-
150°C	0	-	0	-
175°C	0	-	1	C
200°C	0	-	0	-
225°C	0	-	0	-
250°C	0	-	0	-
275°C	1	A	2	C
300°C	1	B	JOB STOPPED	

GROUP III 16 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	0	-	0	-
175°C	0	-	0	-
200°C	0	-	0	-
225°C	0	-	0	-
250°C	0	-	0	-
275°C	0	-	0	-
300°C	0	-	0	-

MFR "A" = MOTOROLA

MFR "B" = SIEMENS

NOTES:

(A) B_V Maximum Limit Failure

(B) B_V Minimum Limit Failure

(C) I_R Miximum Limit Failure

APPENDIX

FAILURE ANALYSIS

FAILURE ANALYSIS

JANTX1N981B

MSFC STEP-STRESS TEST

Date 4 October 1978

J/N 2CN242-31B P/N 1N981 MFR SIEMENS

FAILURE VERIFICATION:

S/N	PIV volts @1.8mA	I_R @ 23 V.dc					Initial Rej. @ Test Seq. No.:	Initial Rej. for:
4625	0.95 R	18 mA					MP-8	I_R
4628	11.60 S	35 mA					MP-10	I_R,BV
4630	9.20 S	50 mA*					MP-8	I_R
		*Cannot reach 23 volts.						
		Limits:	Limit:					
		32.3 to 107.1	500µA Max.					

INTERNAL VISUAL INSPECTION:

All three samples show evidence of metal flow away from the top die contact, and up the internal anode lead. No other significant anomalies were seen. See Figure A-1.

*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)

**h_{FE} trace very leaky.

D = drift H = hysteresis Inv = inversion R = resistive S = soft Uns = unstable

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FAILURE ANALYSIS

JANTX1N981B

MSFC STEP-STRESS TEST

Date 4 October 1978

J/N 2CN242-31B P/N 1N981 MFR MOTOROLA

FAILURE VERIFICATION:

S/N	PIV volts @1.8mA	I_R @ 23 V.dc					Initial Rej. @ Test Seq. No.:	Initial Rej. for:
4677	R (4)						MP-11	I_R,BV
4679	20 S	2.5 mA					MP-11	I_R,BV
4680	8.8 R	17 mA					MP-10	I_R,BV
	Limits:	Limit:						
	32.3 to 107.1	500µA Max						

INTERNAL VISUAL INSPECTION

S/N 4679 has die-attach metal up one edge and reaching the top of the die.

S/N 4680 has an extraneous large silicon chip held by the die-attach metal and touching one corner of the die. See Figure A-2 for typical Motorola construction.

*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)

**h_{FE} trace very leaky.

D = drift H = hysteresis Inv = inversion R = resistive S = soft Uns = unstable

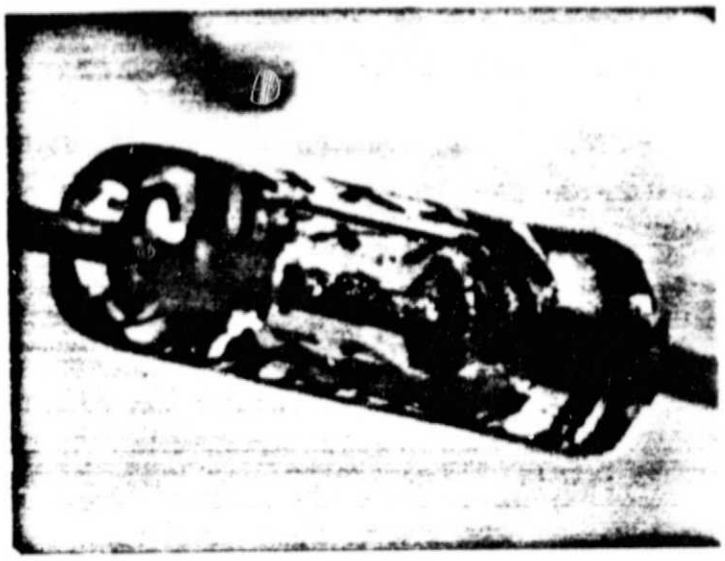

FIGURE A-1

S/N 4628, Typical Siemens Diode, 11X

Notice metal climb on internal anode lead.

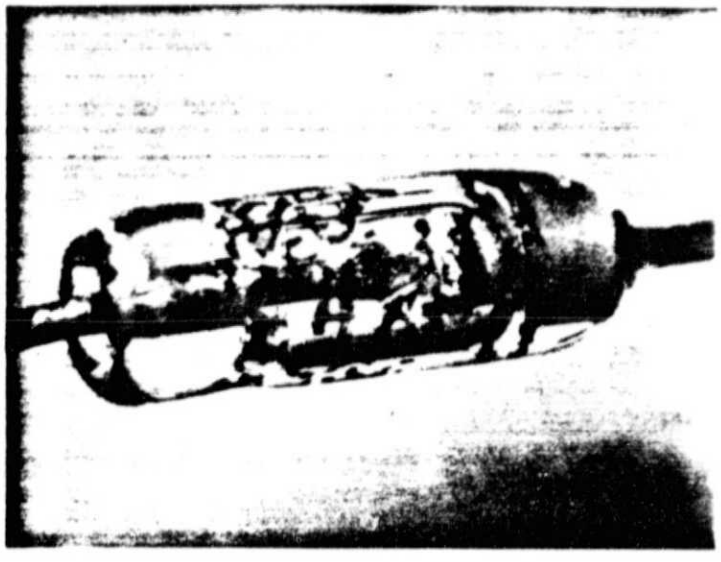

FIGURE A-2

S/N 4675, Typical Accepted Motorola Diode, 10X

ORIGINAL PAGE IS
OF POOR QUALITY

CONCLUSION

All these Siemens and Motorola samples failed due to electrical/ thermal overstress which damaged the diode junctions.

This conclusion is supported by the presence of low breakdowns with soft and resistive curve traces, and the absence of surface leakage. None of the visual defects was sufficient in itself to cause failure. However, the evidence of melting metal, which continued over at least 160 hours, suggests the likelihood that alloying or diffusion of the molten metal into the silicon was the actual failure mode.